

Hydrodynamics modeling of liquid droplet deformation with laser pulses

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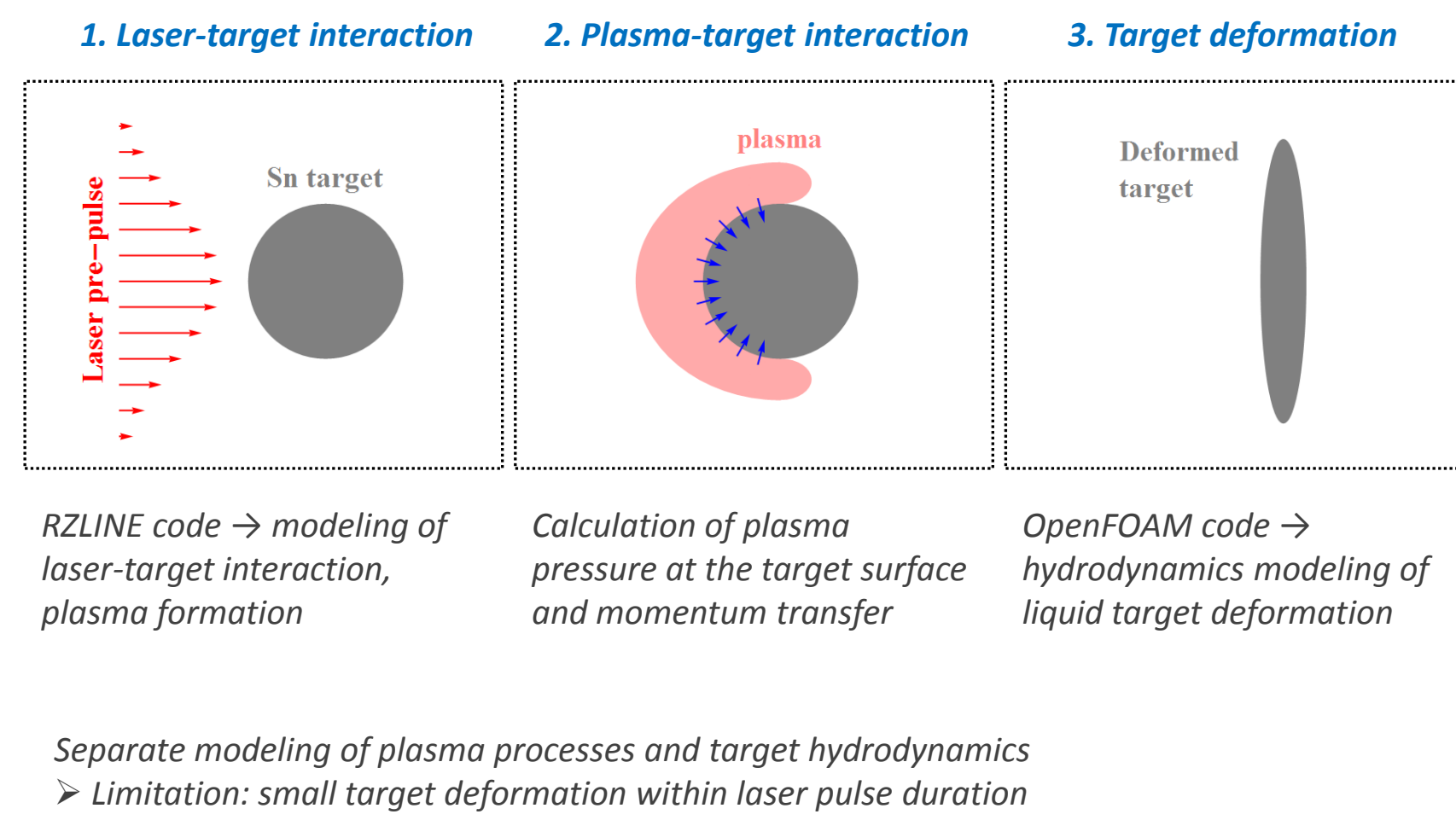
Objective

Investigate influence of the laser pre-pulse on the droplet deformation/fragmentation.

Optimize PP conditions (wavelength, pulse length, pulse energy, pulse shape, etc.) to form desired Sn target morphologies.

The main goal is to create a self-consistent model, which can describe the process of target formation from start to end.

Modeling approach

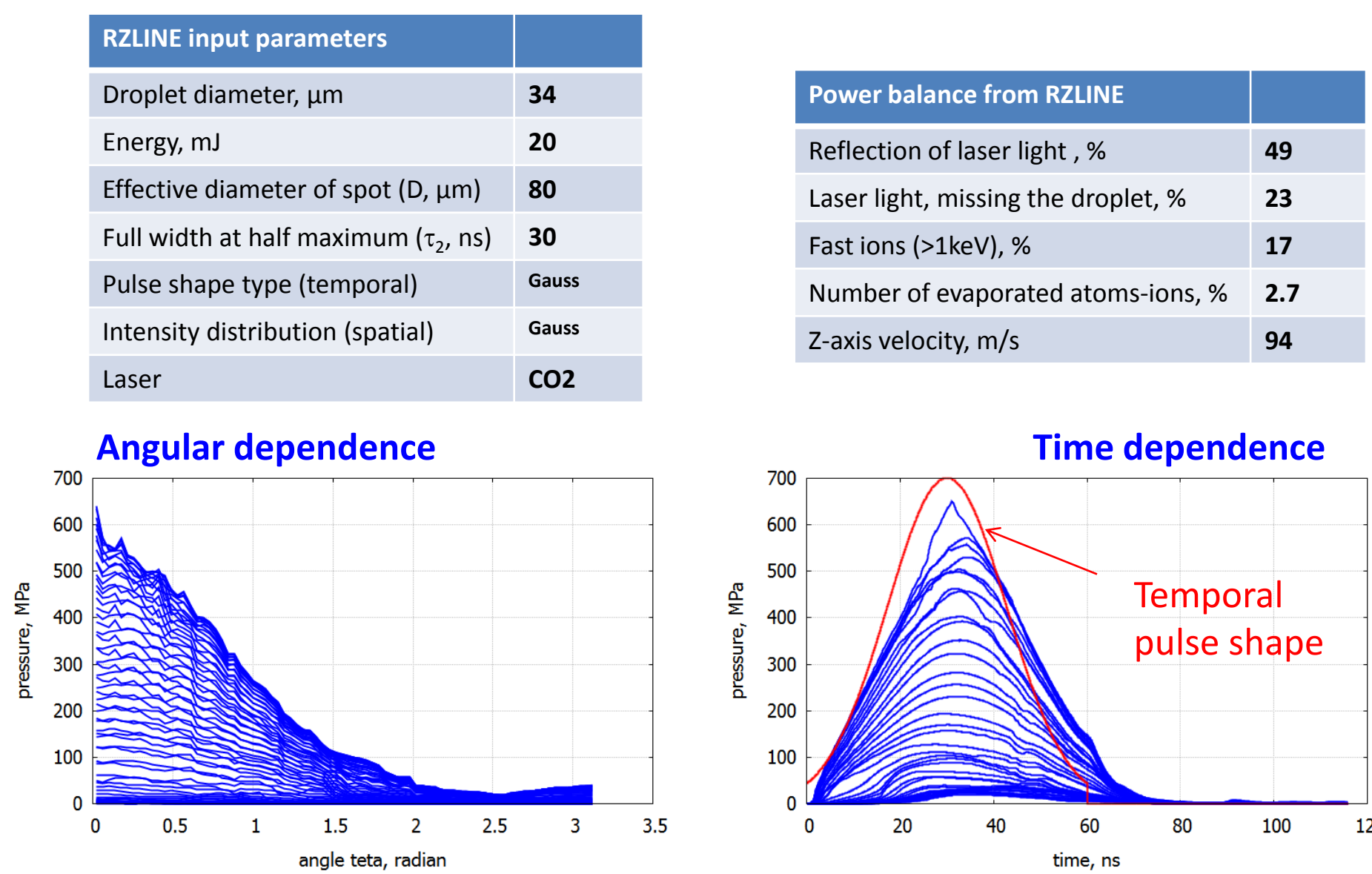


3D Hydrodynamics description

- + Volume of Fluid method
 - + Two phases (Liquid and Gas)
 - + Immiscible fluids
 - + Isothermal
 - + Viscosity
 - + Compressibility
- Regular hydrodynamics
- + Surface tension
 - + Crushing/merge of droplet(s)
 - + Ideal gas equation of state for surrounding gas and constant speed of sound for liquid droplet
 - + Surrounding plasma influence through ablation pressure from RZLINE code
- Specific

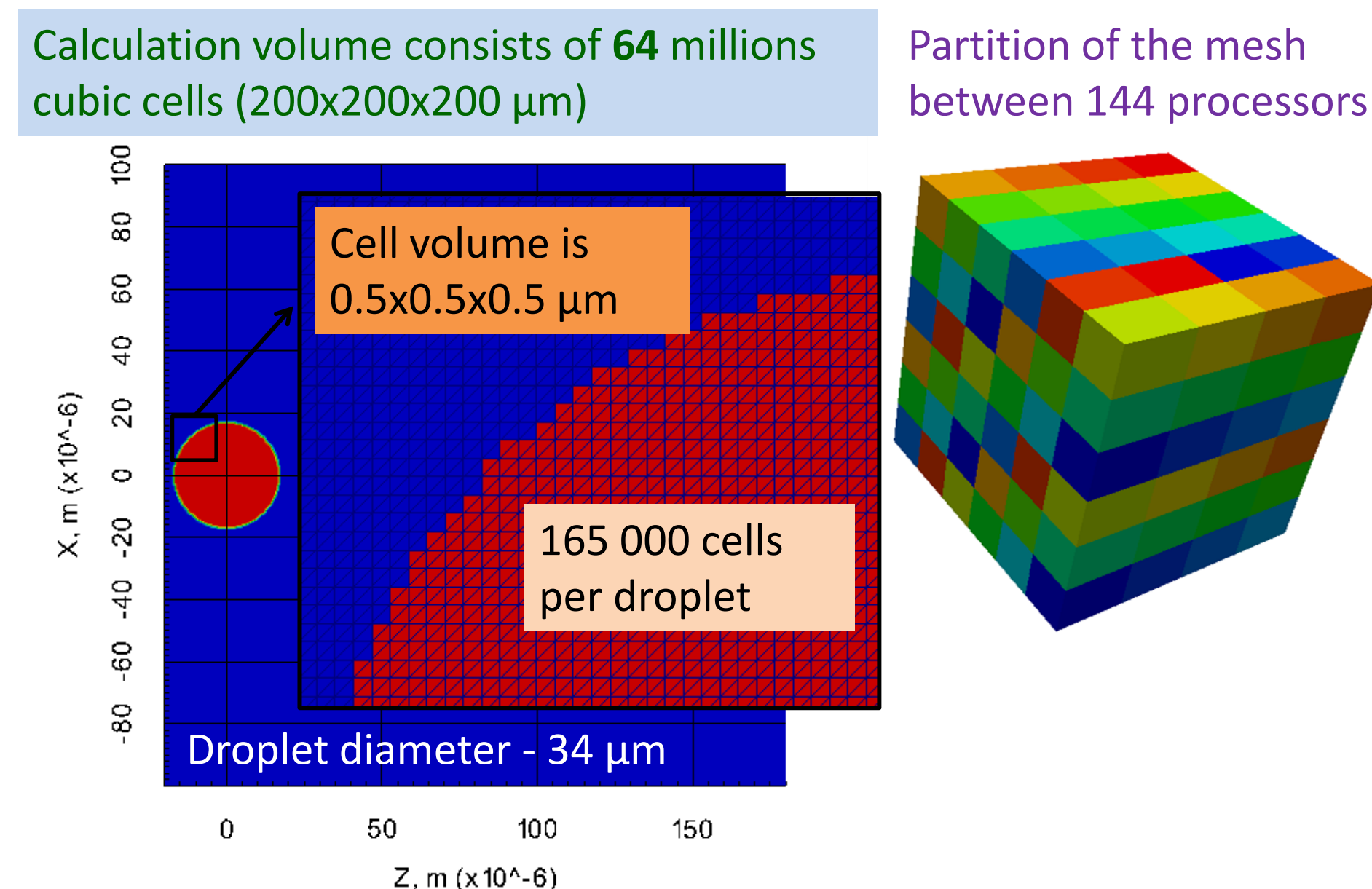
OpenFOAM® OpenFOAM – free to use 3D simulation software library with extensive CFD and multi-physics capabilities
<http://www.openfoam.com/>

RZLINE ablation pressure



RZLINE ablation pressure distribution is critical for the droplet dynamics (hole formation, debris, elongation velocity etc.).

Calculation mesh

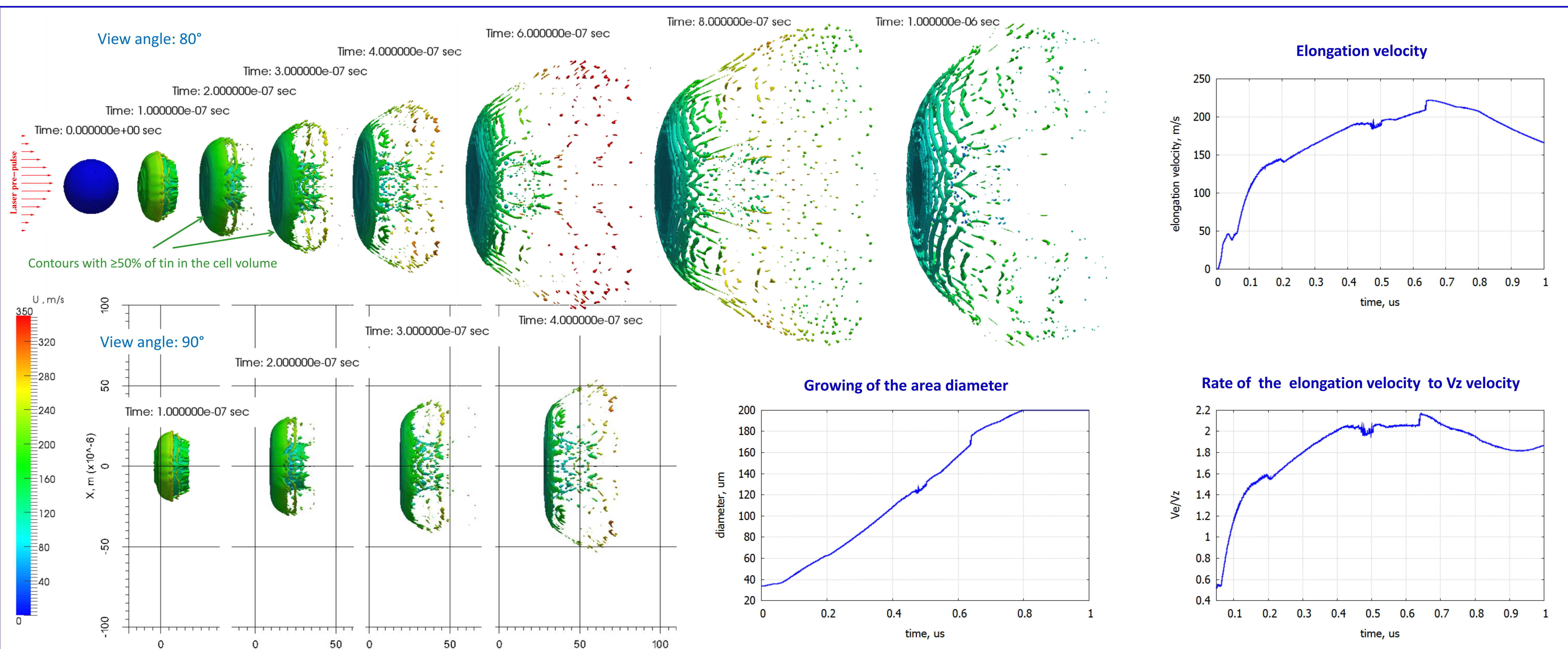


KIAM RAS K-100 Scalable GPGPU-based Hybrid Computing System

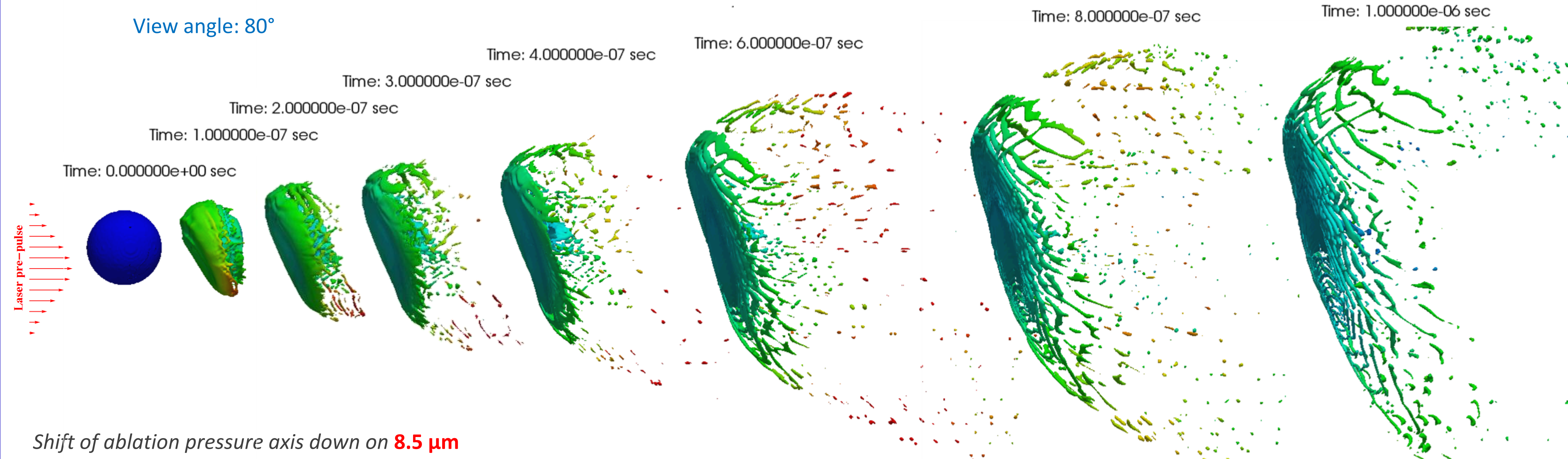
Cores	768 (CPU Intel Xeon X5670)
Peak performance	107 TFlop/s
Memory	6144 GB
Interconnect	Infiniband
Operating System	Linux
Compiler	Intel 11.1, PGI 11.0
Math Library	MKL
MPI	Intel MPI 4.0, OpenMP
HDD	16 TB
Programs	Paraview 3.98, OpenFOAM-2.1.1, OpenFOAM-1.6ext

[1] <http://www.kiam.ru/MVS/resources/k100.html>

Output from OpenFOAM model for central laser pulse



Off axis laser pulse



Conclusions

- A combination of RZLINE & OpenFOAM describes key characteristics of droplet expansion after pre-pulse:
 - ✓ Umbrella-like shape
 - ✓ Hole formation, fragmentation
 - ✓ Elongation velocity

This work is a result of hard work of many people and teams at ISAN, KIAM and ASML.
Special thanks to: Harry Kreuwel, Hanneke Gelderblom and Adam Lassie for stimulating discussions and experimental validation of the model.